Broadway and Cruse Parking Garage

EXHIBIT b to
DATE Jan 25, 2013
HB 5

Preliminary Engineering Report

Prepared For:
Dept of Administration
1310 East Lockey
Helena MT 59620

Prepared By:
Stahly Engineering & Associates, Inc.
3530 Centennial Drive
Helena, MT 59601
(406) 442-8594

MONTANA
MICHAEL JOSEPH MEREDITH
14346PE
LICENSED PROFESSIONAL ENGINEER
4-18-12

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I. Executive Summary

The parking garage located at the SE corner of the Broadway and Cruse intersection in downtown Helena has noticeable signs of deterioration. The purpose of this preliminary engineering report is to analyze different options available to remedy the current situation. In order to get an idea of the structure's current condition, field measurements were taken and initial beam calculations were performed. The data collected along with observations made during site visits provided the basis for the recommendations and alternatives that are provided.

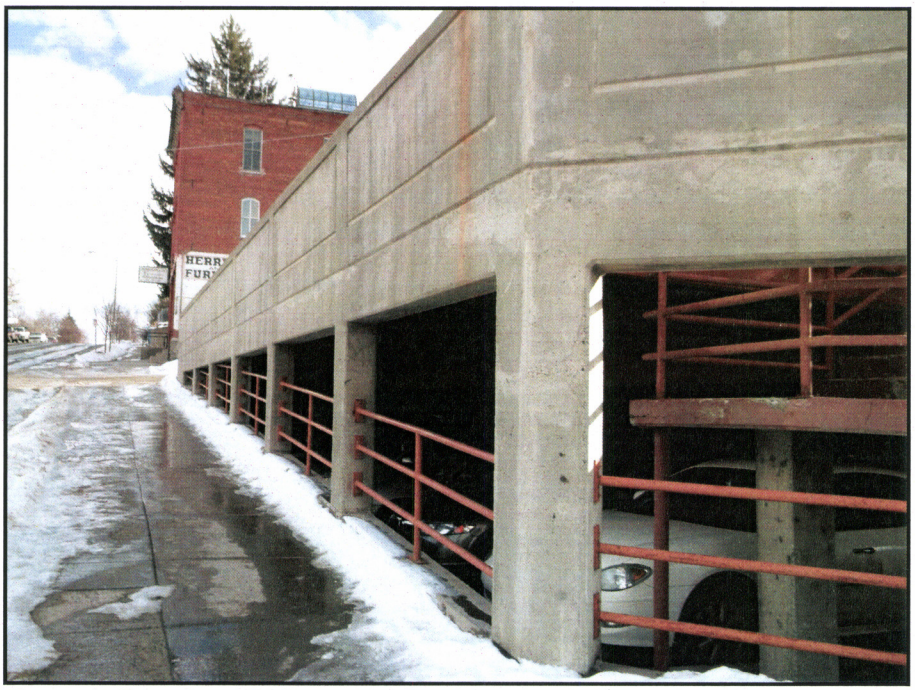


Figure 1 - Broadway & Cruse Parking Garage

Primary Deficiencies:

- The upper deck does not effectively drain water, which appears to be the main cause of the structure's current condition.
- Concrete has deteriorated in several locations.
- The composite concrete deck has extensive corrosion due to the lack of water drainage.
- The steel members are corroded in areas.
- Steel beam connections are corroded in areas and are not capable of flexing under expansion and contraction of the garage.
- There are connections between the steel beams and concrete that are compromised.
- There is not a suitable area for snow storage on the upper deck.

Three alternatives were considered to be the most economical and viable, long-term solutions for the parking garage. The three options considered are:

Alternative 1: Removal and replacement of specific portions of the upper concrete deck that have experienced the most corrosion, as well as a total replacement of the stairs. This alternative would incorporate a retrofitted drainage system.

Alternative 2: Demolition of the upper deck. Reinforcement of Retaining Wall on the South and East side.

Alternative 3: Removal and replacement of the entire upper concrete deck. This would incorporate a new drainage system, and a new configuration and retaining wall to allow for snow storage. The stairs would also be replaced similar to alternative 1.

Alternative 4: Demolition and replacement of entire parking garage including concrete foundation, walls, superstructure, stairs, and deck.

II. Problem Definition

A. Existing Condition

1. Water Drainage

Over the years, there have been drainage issues on the upper deck which have contributed to the deterioration of the concrete deck as well as the steel structure below. Currently, water drains from the parking surface on the upper deck to a location at the North West corner near the stairs. Since the water has not been able to drain effectively off the deck, it has pooled up in areas causing it to leak through the concrete deck.

2. Concrete

The condition of the concrete deck could not be observed due to the asphalt mat. It can be assumed due to the condition of the composite deck underneath that there is considerable deterioration of the concrete in areas, which is continually worsened by the freeze/thaw conditions. The concrete walls were observed to be in good condition, with the exception of concrete in several areas at the beam to concrete connections. The most notable area of concern with the concrete is located at the stairs. This concrete has excessive deterioration and poses a serious safety hazard.

Figure 2 - Concrete Deterioration at Stairs

3. Composite Deck

The deck of this structure is comprised of composite decking. This composite decking acts both as forms during construction, and is also a structural component. Typically, composite decking contains no reinforcing steel. It is important to the structural integrity of the deck for the composite decking to remain in good condition. Due to the water that has infiltrated through the upper deck, the composite decking has experienced considerable corrosion in certain areas.

Figure 3 - Composite Decking

4. Steel Members

The steel members supporting the concrete deck have experienced significant corrosion. The most corroded area is located near the stairs, although there are other areas throughout the structure that show signs of deterioration. One location in particular is at the light post connections that are on the W36x194 beam along the center of the structure. These connections have allowed moisture through the deck and have deteriorated the beams.

Figure 4 - Steel Beam Corrosion

We assume the asphalt mat was added to the upper deck to prolong the life of the parking structure. It is also our assumption that the addition of the asphalt, which weighs approximately 40 psf, likely resulted in the addition of steel plates (3/8" thick, 8" wide) to reinforce the W18x40 steel beams that run in a north - south direction.

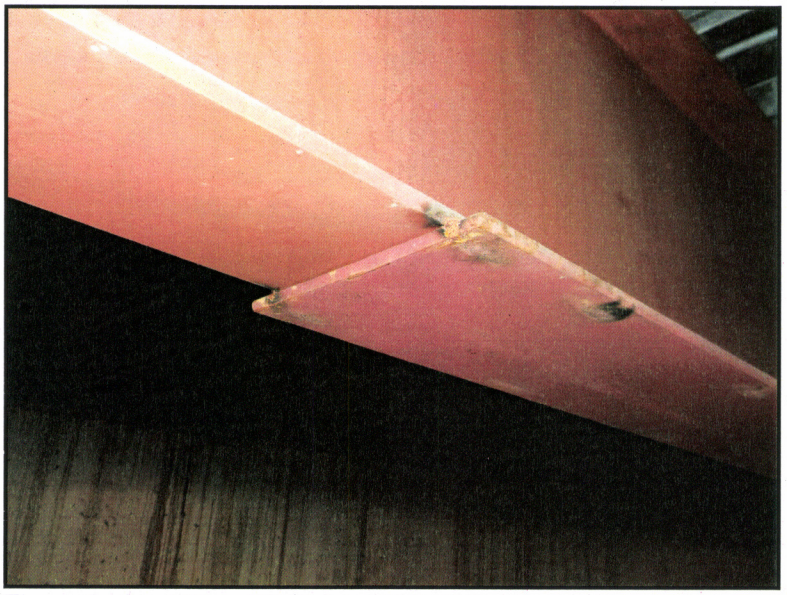


Figure 5 - Steel Plate Welded to W18x40 Beam

5. Steel Member Connections

It was observed that the steel to steel connections lack the ability to allow for thermal movement of the structure. Changes in temperature cause the steel to expand and contract, and lack of flexibility can lead to problems within the steel connections. Gaps could be observed in some of the connections due to this inability for the structure to flex.

Figure 6 – Steel Connections

6. Steel to Concrete Connections

Some of the steel to concrete connections in the structure have also experienced deterioration. This could be caused by water leaking through the deck and causing damage by freeze/thaw conditions. There were also areas that appear to have undergone repair. One connection that had been damaged by spalling was unsuccessfully saw cut in a repair attempt. It appears that this effort was abandoned, and the beam was supported with tube steel that was bolted to the concrete wall (Figure 8).

Figure 7 - Deterioration of Steel to Concrete Connection

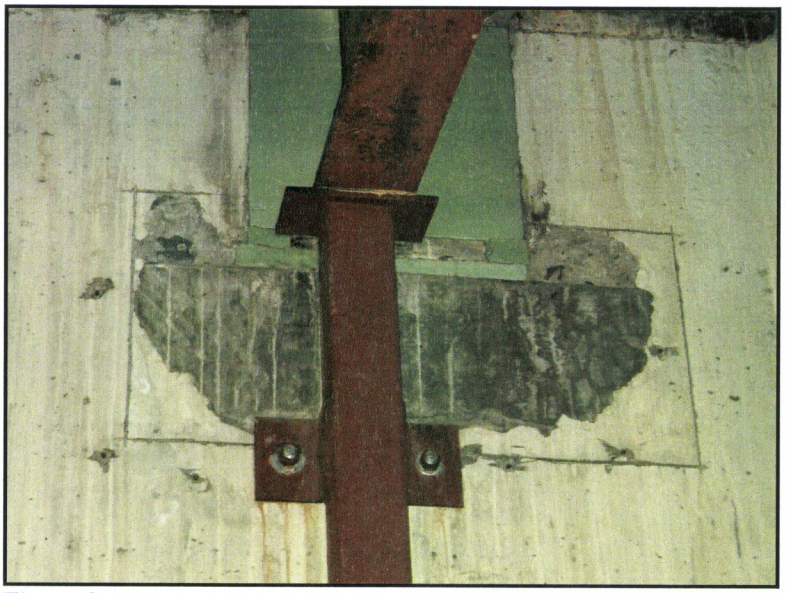


Figure 8 - Previous Repair Work at Steel to Concrete Connection

7. Snow Storage

Part of the drainage issue on the deck is the inability for snow to be stored outside of the parking lot footprint. The result is a large amount of snow that is stored on the South West corner of the lot. This pile of snow melts and drains towards the North West corner, contributing to further water damage.

Figure 9 - Snow Storage Area

B. Impact of Alterations and Repairs

The additional asphalt mat may have been added in efforts to cover up a deteriorating concrete deck, as well as provide a surface that could more effectively drain water to the outlet in the NW corner. Unfortunately the addition of the asphalt did not keep the water from infiltrating down through the deck, and it also added additional loads to the steel substructure. If the asphalt mat is 3" thick, it will add approximately 40 psf. According to the initial beam calculations performed, the weight of the concrete deck plus the asphalt may cause some of the beams to be insufficiently sized. As noted earlier, the W18x40 running North and South have steel plates welded to the bottoms. It is our presumption that these were added in order to increase the beam capacity in an effort to allow the asphalt paving of the top deck. Also, the beam calculations we performed indicate that the W36x194 and the W27x84 beams may be inadequately sized when considering a 40 psf asphalt weight.

C. Necessity for a Solution

Due to the level of deterioration, the parking garage currently poses a safety risk to vehicles and pedestrians. The weakened composite deck and the deteriorated stairs should, at a minimum, be repaired.

In addition, an improved drainage system could help reduce the rate at which the structure continues to degrade. Finally, the current location for snow storage on the site has contributed to the water damage. A new location for the snow storage area would help slow further water damage to the deck, as well as provide more usable space for parking during the winter.

III. Alternative Analysis

The Alternative Screening Process considers all reasonable and economical parking garage improvements and alterations. The garage improvement and replacement options and layouts that were considered are discussed below.

A. Alternative 1 - Partial Rehabilitation of Structure

1. Description

For this structure to be partially rehabilitated, portions of the concrete deck would need to be removed and replaced. This would require saw cutting through the deck to remove specific portions. Any area of the steel deck pans (composite decking) that have visible corrosion would be identified. This method of replacement would require the removal and replacement of the entire section of concrete deck in between the adjacent steel beams even if only a small section of the deck between the beams was corroded. Overall, this option could require the replacement of a larger area of the deck than is visibly corroded due to the manner in which sections would need to be replaced. Additionally, the stairs for the garage are an obvious concern, and removal and reconstruction would be necessary.

A matching asphalt layer would be added on top of the new deck sections in order to match the driving surface with the remaining portion of the deck. An additional expense for this alternative would be the need for strengthening the existing steel beams in order to provide sufficient strength. Concrete cores from the deck would need to be taken and a more detailed structural analysis would need to be performed in order to specify which beams need improvements to continue to safely support the deck.

Select steel beams in this alternative would require sandblasting and painting in order to prevent further corrosion. Since this alternative has the lowest life span, only heavily corroded steel beams in the areas of most concern would be selected to be sandblasted. Out of the roughly 8000 square ft surface area of the steel beams, we are assuming 1000 square ft would require sandblasting.

A retrofitted drainage system could be added to the structure in order to slow the water damage that will continue to affect the garage. This would be a "plumbed" drainage system that would be vulnerable to freezing. A heating system may need to be incorporated with the drains in order to prevent freezing.

This alternative would have an approximate lifespan of five years before additional repairs would be expected for the older sections of the concrete deck. A new retaining wall and pad built for snow storage was not considered for this option due to the short lifespan that the structure would have. If it was decided several years from now that the structure should be completely replaced, the retaining wall and pad could end up being in the way of new construction or major repairs.

2. Schematic Layout

Appendix A shows the layout of the existing structure. Alternative 1 would be identical to the existing layout with the exception of a plumbed drainage system that is added at the approximate locations shown.

3. Construction Problems

Heavy equipment will likely not be able to be placed on top of the deck for demolition due to the unsafe loads it would be placing on the structure. Removing the designated portions of the deck will require concrete saw cutting from above, and may require breaker equipment to reach the areas to be demolished from the edge of the structure.

Additionally, the distance from the bottom level floor to the overhead steel beams gets shorter as you get to the back end (East side) of the structure. This places a constraint on the size of equipment that could be used from underneath in assisting with construction.

4. Cost Estimate

Assumptions for this cost estimate:

- It is estimated that 35% of the surface area of the deck needs to be replaced. This would need to be investigated further in order to identify the exact locations that need replacement.
- 12.5% of the total steel beam surfaces need to be sandblasted
- Annual cost estimate includes cost for the removal of snow from the upper deck as no snow storage area is provided in this option.

Alternative 1 - Partial Rehabilitation

Item No.	Est. Quantity	Unit	Description	Unit Price	Total Price
1	1	LS	Mobilization / Bonding / Insurance	$12,000.00	$12,000.00
2	3600	SF	Removal/disposal of deck	$7.50	$27,000.00
3	3600	SF	Replacement of concrete deck	$9.50	$34,200.00
4	3600	SF	Asphalt replacement	$3.00	$10,800.00
5	1	LS	Repair of Concrete to Steel Connections	$5,000.00	$5,000.00
6	1	LS	Plumbed drainage system	$15,000.00	$15,000.00
7	1000	SF	Sandblasting	$7.50	$7,500.00
8	1	LS	Removal/Replacement of stairs	$15,000.00	$15,000.00
			Sub-Total Construction		$126,500.00
			Construction Engineering/Inspection (20%)		$25,300.00
			Contingencies (15%)		$18,975.00
			TOTAL PROJECT ESTIMATE		**$170,775.00**

Alternative 1 - Equivalent Uniform Annual Cost (EUAC):

Life Span:		5	years			
Initial Cost:		$170,775.00				
Maintenance/snow removal:		$3,000	per year			
EUAC (No Loan)						
	=	$170,775	/	5	+	$3,000
	=	**$37,155**				
EUAC (5% Loan)						
(A/P, 5%, 5)	=	0.23097				
	=	$170,775	*	0.23097	+	$3,000
	=	**$42,444**				

B. Alternative 2 – Removal of Upper Deck

1. Description

This alternative would be the removal of the upper deck of the parking structure, eliminating approximately 33 parking spaces. The concrete slab of the lower parking area would remain as is, with the entrance remaining on Cruse Street. In the area that currently has the entrance to the upper deck, a guardrail or concrete wall would need to be built to provide a safety rail for pedestrians using the sidewalk on Broadway Street. A portion of the guardrail and concrete columns that are currently in place along the structure next to Broadway could possibly be salvaged.

The steel and wood retaining wall that is on the South and East sides of the upper deck would be affected if the entire parking structure was simply removed. Due to the presence of the steel and timber retaining wall that retains the hill above the parking structure, the concrete walls on the South and East side of the existing structure would need to remain in place. Since these walls were likely designed to be restrained at the top (by the upper deck), rather than as cantilevered retaining walls, they would need to be supported by the form of buttresses or helical screws. Since buttresses would protrude out into the available parking spaces, we considered helical screws to be a more appropriate choice for this situation. The retaining wall would be

cored at each helical screw location. Once the screw was installed, a steel plate would be attached to the end holding the wall in position.

This alternative would have an approximate life span of fifty years.

2. Schematic Layout

Appendix A shows the layout of the existing structure. Alternative 2 would be identical to the existing layout of the lower deck.

3. Construction Problems

Similar to alternative 1, heavy equipment will not be able to work from the top of the deck during demolition. Also, the concrete slab on the bottom level would need to be protected from damage during demolition and steel beam removal.

4. Cost Estimate

Assumptions for this cost estimate:

- Helical screws would be needed approximately every 12' for both 100' sections of concrete wall to remain
- A 30' concrete wall or guard rail extension would need to be placed in order to block off the existing entrance to the upper deck.
- Annual cost estimate includes cost for the removal of snow since no snow storage area is provided in this option.

Alternative 2 - Removal of Upper Deck

Item No.	Est. Quantity	Unit	Description	Unit Price	Total Price
1	1	LS	Mobilization / Bonding / Insurance	$16,500.00	$16,500.00
2	10304	SF	Removal/disposal of deck	$7.50	$77,280.00
3	1	LS	Removal of Steel beams	$10,000.00	$10,000.00
4	16	EA	Helical Piers	$4,000.00	$64,000.00
5	1	EA	Concrete wall / Guardrail Extension	$10,000.00	$10,000.00
			Sub-Total Construction		$177,780.00
			Construction Engineering/Inspection (10%)		$17,778.00
			Contingencies (10%)		$17,778.00
			TOTAL PROJECT ESTIMATE		**$213,336.00**

Alternative 2 - Equivalent Uniform Annual Cost (EUAC):

Life Span:		50	years			
Initial Cost:		$213,336.00				
*Parking space rental:		$19,800	per year			
Maintenance/snow removal:		$1,500	per year			
EUAC (No Loan)						
	=	$213,336	/	50	+	$21,300
	=	**$25,567**				
EUAC (5% Loan)						
(A/P, 5%, 50) =		0.05478				
	=	$213,336	*	0.05478	+	$21,300
	=	**$32,987**				

*Parking space rental = $50/month per space @33 spaces = $19,800

C. Alternative 3 – Removal and Replacement of Concrete Deck

1. Description

This alternative would consist of removing and replacing the entire concrete deck. The new deck would incorporate improved surface drainage, which would not require "plumbed" components potentially needing heat to prevent freezing. Like alternative 1, a new set of stairs would be incorporated into the new deck.

Following deck removal, certain steel to steel connections could be altered in order to allow for thermal movement. This would entail shoring up the steel beams and switching the connections out with slotted connection pieces that give the structure the capability to move with thermal expansion and contraction.

Sandblasting and painting of the steel beams throughout the structure would also be required. It is assumed that removing the entire deck will expose more steel beams that have experienced corrosion and will require sandblasting. We are assuming that around 3000 square ft of sandblasting will be required. The criteria for selecting beams requiring sandblasting would also allow for less corroded beams to be included since a longer service life would be required from the steel structure.

This alternative would include design and construction of a snow storage area. This would likely consist of a new location for a retaining wall and level pad for snow storage on the SW corner.

The improvements gained by alternative 3 would give the parking garage an approximate lifespan of twenty five years.

2. Schematic Layout

Alternative 3 would be identical to the existing layout with the addition of a snow storage area on the South West corner of the structure. Appendix B shows a possible configuration and location for the retaining wall.

3. Construction Problems

Similar to Alternative 1, heavy equipment will be restricted from working on top of the deck due to safety concerns, which will again make removal of the deck more difficult.

4. Cost Estimate

Assumptions for this cost estimate:

- 37.5% of the total steel beam surfaces need to be sandblasted
- Approximately 110 steel to steel connections with slots to allow thermal expansion would be needed.
- Retaining wall / footer would require approx 50 cubic yards of concrete, 4500 lbs of steel, and 500 CY of structure excavation.

Alternative 3 - Removal and Replacement of Concrete Deck					
Item No.	**Est. Quantity**	**Unit**	**Description**	**Unit Price**	**Total Price**
1	1	LS	Mobilization / Bonding / Insurance	$29,000.00	$29,000.00
2	10304	SF	Removal/disposal of deck	$7.50	$77,280.00
3	10304	SF	Replacement of concrete deck	$7.00	$72,128.00
4	110	EA	Replacement of Steel plate connections	$200.00	$22,000.00
5	1	LS	Repair of Concrete to Steel Connections	$5,000.00	$5,000.00
6	3000	SF	Sandblasting & Painting	$7.50	$22,500.00
7	1	LS	Removal/Replacement of stairs	$15,000.00	$15,000.00
8	500	CY	Structure Excavation	$35.00	$17,500.00
9	50	CY	Concrete (Retaining Wall)	$600.00	$30,000.00
10	4500	LBS	Reinforcing Steel (Epoxy)	$1.10	$4,950.00
			Sub-Total Construction		$295,358.00
			Construction Engineering/Inspection (20%)		$59,071.60
			Contingencies (15%)		$44,303.70
			TOTAL PROJECT ESTIMATE		**$398,733.30**

Alternative 3 - Equivalent Uniform Annual Cost (EUAC):

Life Span:		25	years			
Initial Cost:		$398,733.30				
Maintenance:		$2,000	per year			
EUAC (No Loan)						
	=	$398,733	/	25	+	$2,000
	=	**$17,949**				
EUAC (5% Loan)						
(A/P, 5%, 25) =		0.07095				
	=	$398,733	*	0.07095	+	$2,000
	=	**$30,290**				

D. Alternative 4 – Complete Replacement of Parking Garage

1. Description

Alternative 4 is a long term alternative that would require complete demolition of the parking structure including deck, beams, and concrete walls. The design could incorporate a drainage system, snow storage area, and new layout and size depending on the needs of the owner. This alternative would have an anticipated lifespan of fifty years.

2. Schematic Layout

Alternative 4 would be designed to meet the needs of the owner. This could be identical to the existing layout, and also include a retaining wall for snow storage area. For the purpose of comparing the alternatives within this report, it is assumed that the replacement parking structure would be very similar to the existing layout.

3. Construction Problems

Due to the topography of the site, the excavation required to build a new structure could require soil shoring (possibly shotcrete). The purpose of the shoring would be to prevent the existing steel and timber retaining wall that wraps around the South and East sides of the upper parking level from being destabilized as the adjacent areas are excavated.

Figure 10 – Steel and Timber Retaining Wall

4. Cost Estimate

Assumptions for this cost estimate:

- Parking structure will remain similar to existing structure and layout
- Snow storage area would require retaining wall similar to Alternative 2.
- Demolition cost is less for this option than in the other alternatives because no care needs to be taken to maintain existing components.

Alternative 4 - Complete Replacement of Parking Garage

Item No.	Est. Quantity	Unit	Description	Unit Price	Total Price
1	1	LS	Mobilization / Bonding / Insurance	$85,000.00	$85,000.00
2	1	LS	Demolition	$50,000.00	$50,000.00
3	10304	SF	Replacement of structure	$60.00	$618,240.00
4	2000	SF	Shoring (shotcrete)	$25.00	$50,000.00
5	500	CY	Structure Excavation	$35.00	$17,500.00
6	50	CY	Concrete (Retaining Wall)	$600.00	$30,000.00
7	4500	LBS	Reinforcing Steel (Epoxy)	$1.10	$4,950.00
			Sub-Total Construction		$855,690.00
			Construction Engineering/Inspection (20%)		$171,138.00
			Contingencies (15%)		$128,353.50
			TOTAL PROJECT ESTIMATE		**$1,155,181.50**

Alternative 4 - Equivalent Uniform Annual Cost (EUAC):

Life Span:	50	years			
Initial Cost:	$1,155,181.50				
Maintenance:	$1,000	per year			
EUAC (No Loan)					
=	$1,155,182	/	50	+	$1,000
=	**$24,104**				
EUAC (5% Loan)					
(A/P, 5%, 50)=	0.05478				
=	$1,155,182	*	0.05478	+	$1,000
=	**$64,281**				

IV. Preferred Alternative

A. Summary of Alternative Costs

Alternative	Total Cost	EUAC (no loan)	EUAC (5% loan)
No 1. Partial Rehabilitation	$170,775	$37,155	$42,444
No 2 Remove Upper Deck	$213,336	$25,567	$32,987
No 3. Remove and Replace Concrete Deck	$398,733	$17,949	$30,290
No 4. Complete Replacement of Parking Garage	$1,155,182	$24,104	$64,281

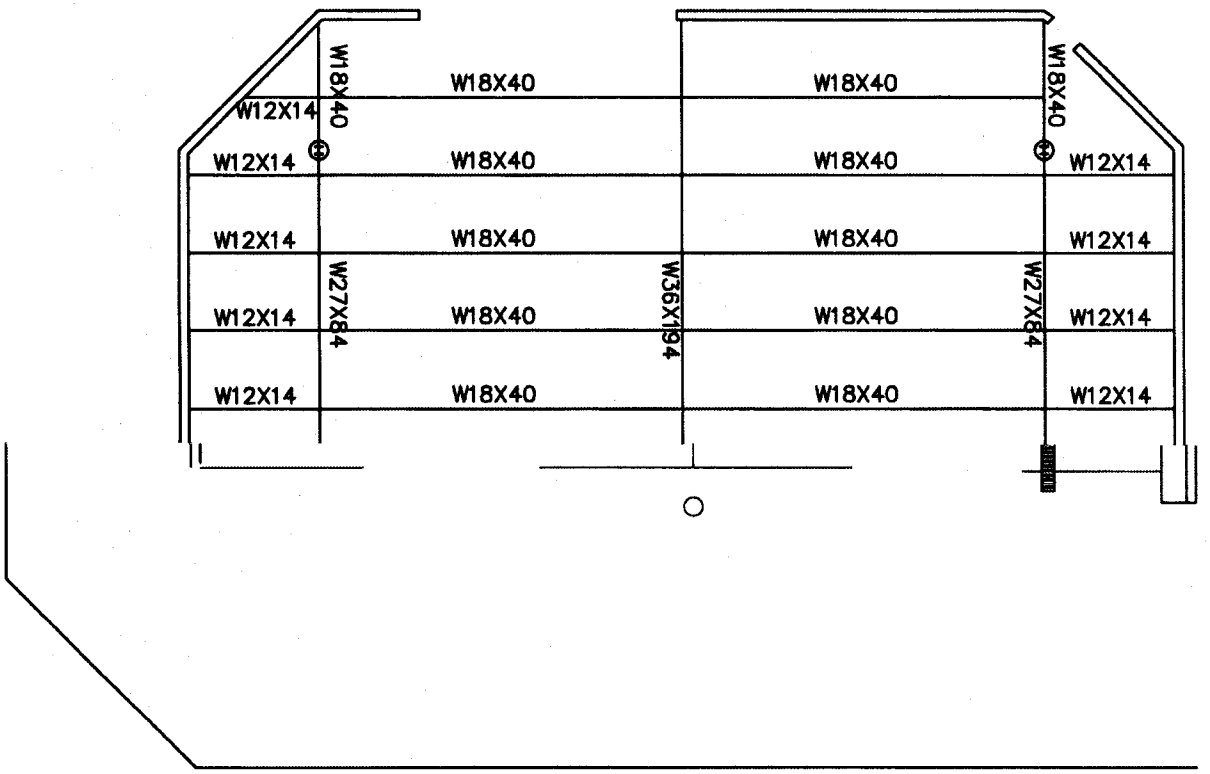
B. Recommended Alternative

Based upon our field inspections, initial structural analysis of the steel structure, and cost estimates, the repair option we recommend is Alternative 3.

Alternative 4 is not considered to be a good option because it does not lower the annual cost. Since the concrete walls and steel beams in the existing structure can continue to perform their function with relatively minor repairs, replacing these components would not provide a cost savings even though a new structure could have a fifty year life span.

Although the initial cost of Alternative 3 is higher than Alternative 1 & 2, we believe the additional upfront cost is justified. Alternative 1 has a short life span before major repairs would be necessary, and also has the highest EUAC of all the options. While alternative 2 provides a longer term solution at a lower up front cost, the continual cost of renting additional parking spaces is a major factor that contributes to the yearly cost associated with this option.

Ultimately, our opinion is that Alternative 3 would be the best alternative financially as well as functionally.



SHEET #####

DESIGNED JDS
DRAWN X
CHECKED X
DATE 3/19/2012

APPENDIX A

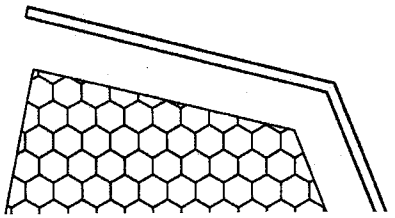
BROADWAY AND CRUSE PARKING GARAGE
HELENA, MT

ISSUE			
No.	DATE	DESCRIPTION	BY
1	3/15/12		JDS

STAHLY ENGINEERING & ASSOCIATES
Professional Engineers
& Surveyors

7585 Shedhorn Drive
Bozeman, MT 59718
Phone:(406)522-9526
Fax:(406)522-9528
E-MAIL seaengnr@MT.net

3530 Centennial Dr.
Helena, MT 59601
Phone:(406)442-8594
Fax:(406)442-8557
E-MAIL seaengnr@MT.net



RETAINING WALL TO PROVIDE SNOW STORAGE PAD

SHEET ####

DESIGNED JDS
DRAWN X
CHECKED X
DATE 3/15/2012

APPENDIX B

BROADWAY AND CRUSE PARKING GARAGE
HELENA, MT

ISSUE

No.	DATE	DESCRIPTION	BY
1	3/15/12		JDS

STAHLY ENGINEERING & ASSOCIATES
Professional Engineers
& Surveyors

7585 Shedhorn Drive
Bozeman, MT 59718
Phone:(406)522-9526
Fax:(406)522-9528
E-MAIL seaengnr@MT.net

3530 Centennial Dr.
Helena, MT 59601
Phone:(406)442-8594
Fax:(406)442-8557
E-MAIL seaengnr@MT.net